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ABSTRACT

This publication is one in a series of 12 giving the recommendations that were made for a broad and balanced education program in science for young people. Section one of this guide deals with the factors that were the reason for the implementation of a review process, a listing of financial sponsors and other "in kind" help from industry, the organizational structure, and the successes and failures of the committee. There are 16 recommendations regarding the objectives that should have been achieved by students listed in section two. Section three contains resource implications for: (1) children; (2) science teachers; (3) science departments; (4) schools; (5) local education authorities; and (6) the government. Included are an appendix containing a summarized reply from the Rotherham Metropolitan Borough Council Department of Education to the document on curriculum proposals for science education, a list of sources which were used during the research and developmental stages of the review, a list of references, and an index. (RT)

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SECONDARY SCIENCE CURRICULUM REVIEW

SSCR

BETTER SCIENCE: Key proposals

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Curriculum Guides

SECONDARY SCIENCE CURRICULUM REVIEW

SSCR

BETTER SCIENCE:

Key proposals

Curriculum Guide 1

Compiled by Mick Michell

Heinemann Educational Books/Association for Science Education
for the School Curriculum Development Committee

The Secondary Science Curriculum Review has run from 1981–1986 (Phases 1 and 2), with a dissemination phase (Phase 3) from 1986–1989.

The Review operates under the aegis of the School Curriculum Development Committee and is supported by the Association for Science Education. In addition, it receives or has received support from the Department of Education and Science, local education authorities, the Schools Council (Phase 1), the Northern Ireland Council for Educational Development (Phase 2), the Health Education Council (Phase 2), industry (particularly British Petroleum), the Department of Trade and Industry, and the Independent Broadcasting Authority.

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Foreword

This is the first in a collection of twelve Curriculum Guides from the Secondary Science Curriculum Review, published jointly by Heinemann Educational Books and the Association for Science Education.

A *Directory of Resources* and a book, *Better Science: Making it happen*, which tries to set the Review's recommendations in the context of the whole school, will appear at the same time as the Guides. These will, when taken with earlier and forthcoming SSCR publications, including those from local groups, constitute the recommendations which the Review is making towards a broad and balanced science education for all the young people in our schools. The series title, 'Better Science' is thus both apposite and self-explanatory. It is hoped that the current phase of the Review (1986–89) will achieve successful implementation of the recommendations.

But what is the status of these new publications apart from reflecting the formal approval and support of our major sponsors, the School Curriculum Development Committee and the Association for Science Education? From what sources have the recommendations within them emanted? Those readers unfamiliar with the history of the SSCR will find it explained within the Guides; but most will be aware that it set out as a project which tried to involve fully the practising teacher in the development of solutions to the problem of science for all. Thus, although the Guides have been compiled principally by the Central Team of the Review, they draw on the work of thousands of teachers in working groups over the past four years. Although the work of many of the groups is referred to in the Guides, it is not possible to refer to it all. In the *Directory of Resources* readers will find details of what many of these groups have produced. The writing of these Guides, however, would not have been possible without the groups' existence and the Review Central Team hopes that the content of the Guides truly reflects their work. Thus the pronoun 'we', used within them, often reflects the view, gleaned over five years of consultation, of the practising teachers involved with the Review. On other occasions it can represent the views of the SSCR as constituted by the Central Team and Steering Committee and it is hoped that particular usage will be apparent from the context.

Jeff Kirkham
Mick Michell
Jeff Thompson
Dick West
(SSCR Curriculum Guide Editors)

Acknowledgements

The ideas presented in these Guides are not only the result of the work of SSCR groups. Their production has also relied on considerable discussion in, and on the collective wisdom of, the SSCR Central Team:

Beverley Bell (CLIS Project Coordinator 1984–85), Di Bentley (Research and Development Officer, Health and Science Education 1983–86), Paula Bower (Information Officer 1984–86), Christine Ditchfield (Southern Regional Project Officer), Dave Ebbutt (Evaluation Officer 1983–86), Kate Ellington (North West Regional Project Leader 1983–86), John Heaney (Midlands Regional Project Officer), Joseph Hornsby (North Regional Project Officer), Ruth Jarman (Northern Ireland Regional Project Leader 1983–84), Jeff Kirkham (Director from 1986; Director Designate 1985–86), Anna Larter (Project Administrator), Mick Michell (Director 1985–86; Deputy Director 1982–85), Val Oldham (CLIS Project Coordinator 1985–86), Denis Stewart (Regional Project Officer Wales & West Midlands from 1986; Northern Ireland Regional Project Leader 1984–86), Jeff Thompson (Chairman, SSCR Steering Committee), Mike Watts (Anglia Regional Project Leader 1983–86), Dick West (Director 1981–85), Cathy Wilson (ASE/SSCR Liaison Officer).

The Review is also indebted for the support and perceptive contributions of the SSCR Steering Committee (Phase 2):

Professor J.J. Thompson (Chairman), Mr W.F. Archenhold (representing the Examination Boards), Dr M. Birchenough (School Curriculum Development Committee), Professor P.J. Black (Standing Conference on University Entrance), Professor R. Blin-Stoyle (School Curriculum Development Committee), Dr J. Brown (School Curriculum Development Committee and Industry), Ms C.M. Edwards (Association for Science Education), Mr V. Green (HMI), Mr G.C. Hill (Association for Science Education), Mr E.O. James (School Curriculum Development Committee), Dr R.T.B. McClean (Northern Ireland Council for Educational Development), Mr J. Nellist (Association for Science Education), Mr S. Pain (Health Education Council), Mr N.J. Sanders (Department of Education and Science – until 1985), Mr M. Capey (Department of Education and Science – from 1985), Mr K. Weller (Secondary Examinations Council).

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We also record our considerable debt to Anne Harvie, Bee Ogilvie and Mellony Rose, without whose tremendous commitment and professionalism the production of these Guides would not have been possible.

Jeff Kirkham
Mick Michell
Jeff Thompson
Dick West

The compiler is grateful to the Rotherham Metropolitan Borough Council both for their work in compiling a reply to the SSCR proposals and for their permission to include parts of the reply in the Appendix of this Curriculum Guide. He is also very grateful to Trevor McClean and Fred Riddell for their perceptive comments.

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SECTION ONE

The Secondary Science Curriculum Review

Why the Review was set up

During the late 1970s, the impetus for curriculum development provided by the Nuffield Foundation started to wane. Although there was still much activity in the form of the Science 13–16 Project and many schools were using Nuffield materials, at least in an informal way, the current questions in science education were not directly Nuffield-related. A great deal of effort was being expended by the Association for Science Education (ASE) in investigations into the science curriculum (**1.1**) (**1.2**). The issues involved might perhaps be summarised as four questions:

> What sort of science education is on offer for those of our school population who are not academically able?
> In what ways can a broad and balanced science education be provided for all our young people without distorting the balance of their overall curricular provision?
> How, in an era of rapid change in science, technology and society, can school science be brought, and kept, up-to-date?
> What can be done about the increasing amount of research evidence which shows:
> poor understanding of new science initiatives by employers, parents, universities and children;
> poor uptake at the chalk-face of carefully worked out and extensively trialled teaching material?

Box 1 *A summary of the ASE's questions*

These factors were the background to the setting-up, in 1981, of the Secondary Science Curriculum Review. It is not the purpose of this Curriculum Guide to discuss the history of the Review's formation. It is rather to acquaint the reader with the way in which the SSCR has attempted to answer these and other questions about science education. Many of our readers will, of course, have no need to go further with this chapter, for three thousand or more of them have been in some way involved with the SSCR over the past four years. However, we are conscious of the large number of science teachers and others who may have had no access to the Review and it is to them that this section is addressed.

Where the money has come from

Centrally, the Review has been sponsored by

The Association for Science Education (ASE)
The Department of Education and Science (DES)
The Health Education Council (HEC)
The Northern Ireland Council for Educational Development (NICED)
The Schools Council for Curriculum and Examinations (until March 1984)
The School Curriculum Development Committee (SCDC) (from April 1984).

The Review could not even have commenced its work without the finance and other resources provided by the above bodies. In addition, finance and other essential help 'in kind' has come from industry, notably

British Petroleum (extensive finance for teacher secondment)
British Gas
Imperial Chemical Industries
The General Electric Company
The Electricity Council.

However, as will be seen in more detail below, these resources have been greatly enhanced by input from Local Authorities. From the travelling expenses of their teachers to reprographic costs, from in-service courses to the generous allowance, in many cases, of full or part-time teacher release, the LEA contribution must not be undervalued. Many LEAs and most of the above sponsors will be continuing their support into the Review dissemination phase, which will follow the publications of these Curriculum Guides.

Organisation of the Review

Early in 1982, the first Director of the Review, Dick West, and the SSCR Steering Committee decided that the model of curriculum development adopted would not be the classic centrally-based 'Research, Development and Dissemination' model used by most earlier projects. Instead, a model which utilised its central resource to stimulate and support development at the periphery was selected. The idea was to offer all practising teachers, working in their schools and authorities, a chance to contribute to the development work necessary to create suitable science courses for all young people.

An invitation was therefore sent to all Chief Education Officers and Science Advisers in

England and Wales, as well as to Education and Library Boards in Northern Ireland. This document (**1.3**) laid out the aims of the Review and requested resources to allow the activity to take place in the receiving LEA. It was agreed (**1.4**) that, at a time of financial constraint, the Review would do well to engender activity in thirty of the one hundred and four Local Authorities. That working groups were eventually formed in more than seventy, is a tribute not only to the commitment of the Review's Central Team but also to the wisdom and hard work of many people at the periphery, not least the Local Authority Science Advisers. At the same time as the network was being set up, Review personnel were being appointed to the Central Team, so, by mid-1983, the Review could be represented by the model shown below.

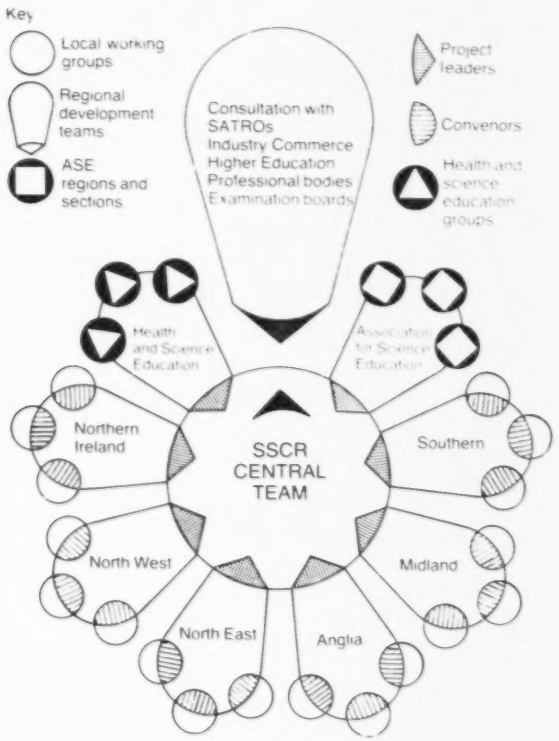

Fig. 1 A model of the Secondary Science Curriculum Review

It may be seen that it was not only in Local Authorities that activity was taking place. The ASE offered its members, primarily practising teachers, another opportunity to take part in group activity through its regional network. Though the number of groups set up by this mechanism was comparatively small, teachers from LEAs not participating in the Review and teachers who preferred not to join in the work of their own LEA were provided with a valuable mechanism for participation. More of the ASE's scarce resources were thereby also committed to the work of the Review. The contribution of the Health Education Council (HEC) is discussed later in this section.

At its peak, the Review consisted of 271 working groups (**1.5**). Each of these was composed of teachers, perhaps with some others, and had an elected Convenor and/or Secretary. Each group had allocated itself a task concerning science education in its own school, Local Authority or ASE region. It had negotiated a descriptive 'working brief' with the Review and was working, mostly in its members' own spare time, at its selected problem. A list of a few working group titles (**1.6**) gives an evocative flavour of the range of activities:

Problem-solving via industrial archaeology
A core and options approach to science 14–16
10+ science
Medical technology
Science for half our children
Developing alternative assessment techniques.

The groups received varying levels of support. Few would be able to say that they received no help at all. Some Authorities were able to provide a small amount of reprographic help, a venue for meetings and travelling expenses for teachers. Others were able to find the funds to allow groups to be released from school on a more or less regular basis, with or without supply cover. Some built Review activities into their in-service budgets and others found the resources to release one or two individuals on a full or part-time basis. These latter individuals were able to support the work of several groups within their Authority and became known as Coordinators.

As Fig. 1 shows, all LEA-based groups fell into one of the Review's six geographical regions. Activity in each region was coordinated by a full-time Regional Project Leader, who was a member of the SSCR Central Team. Northern Ireland became one of the Review's regions as a result of financial support for the SSCR to the extent of 4 per cent of total cost; its Regional Project Leader receiving the additional benefit of a Regional Steering Committee, whose participation has been of great value. The ASE activity mentioned above was coordinated by the Deputy General Secretary of the Association, who was seconded to work with the Review for two days of her working week.

The participation of the Health Education Council also deserves mention. Through a six-figure contribution over three years, the appointment and support of a Research and Development Officer for Health and Science Education became possible. She has worked in every region and often across regions. Sometimes she has supported groups dealing exclusively with health and science education issues. In many

more instances, however, her time has been spent alerting groups to the health education aspects of their chosen task and consequently supporting them in the development of such aspects.

Successes and failures

Though originally, by any measure, a high-risk model, the Review has been a marked success. At a time when teachers were having to deal with an unprecedented number of new initiatives, many still welcomed the chance to be actively involved in science curriculum development. Their enthusiasm can only be admired. It is hoped that the large number of teachers who, mainly by virtue of having participated in the Review, are committed to its aims, will provide a pool of knowledge and enthusiasm from which dissemination and implementation of the Review's recommendations can be accomplished. Research into the success of earlier curriculum development initiatives indicates that such projects create teachers who might be described as 'converts', against whom the majority inevitably react and build barriers (**1.6**) (**1.7**). At the very least, the large number of teachers participating in Review activities ought to allow the Review 'converts' a better numerical chance against those who fear change or reject it. An important group of science teachers whose opinion is not represented in the Review to any great extent is that in the independent sector. Major efforts are clearly needed in the dissemination phase to involve them.

The Review has in one sense been rather unlucky. For a significant slice of its life so far it has been the unhappy victim of a dispute between school teachers and their employers over salaries and working conditions. Under such circumstances it has been understandable that many teachers have wished to suspend their Review activities. The present consequences of this problem may be summed up as follows:

1 When the working groups came under pressure as the teachers' dispute worsened, they often tried to continue the main body of their Review work but were unable to give time to the evaluation of their projects and, more especially, to an assessment of the working model of the SSCR from within the working group. With the benefit of hindsight, the Review might have chosen a less ambitious working model and a less demanding system of evaluation had it known the serious nature of the coming dispute. (**1.8**). Inevitably, therefore, the process of the Review has been much less thoroughly analysed in the most important area, that of practising teachers in schools, than was hoped. The results from the working groups were originally intended to be subject to classroom trials and peer group evaluation at several levels (**1.9**) but these intentions were, again, only partially fulfilled.

2 At its peak, 271 working groups were in existence under the auspices of the Review (**1.5**). At the time of writing, it is thought that only about 75 of these will succeed in producing an outcome suitable for inclusion in the first issue of the SSCR **Directory of Resources**. Some of the 'missing' material will doubtless be included in the two annual Directory updates, but it is certain that some group work will disappear altogether, a sad waste of human effort. Also, some groups which *have* been able to produce materials had to reduce the scope of their original project, but it is hoped that these might achieve their original intentions through a resumption of activity in the near future.

3 The effect of the teachers' dispute has not been evenly spread. It was possible, before it began, to identify a certain unevenness in involvement in the Review amongst LEAs. For example, activity in Wales was not extensive, and there was more involvement in the south than in the north of the country. Unfortunately, the dispute affected some of the Review's weaker areas so severely that there is now an identifiable north/south divide in Review output.

4 A reduction in the quality and scope of the working group results has meant a reduction in the authority, at least in the written sense, with which the Review can speak for the science teaching profession. The Curriculum Guides which accompany this one have all had to limit their evidence from practising teachers to that available. As a result, the richness and diversity of examples, which would more truly reflect the professionalism and imagination of science teachers, has been reduced.

However, it would be unfair to sound in any way depressed by the achievements of the Review in the five years for which it has been operating. The results have shown clearly the wisdom of putting the onus of curriculum development on to those who meet the problems every day, the classroom teachers. In the circumstances, they have performed magnificently and shown the way forward for curriculum development in all areas for the rest of this century.

SECTION TWO

Science for all: SSCR recommendations

The Secondary Science Curriculum Review recommends that every secondary school organises the provision of science education so that the following objectives are achieved as soon as possible. Ideas for their achievement are set out in the accompanying Curriculum Guides.

1 Every young person, regardless of gender, ethnic origin, cultural or religious background, is entitled to science education as a part of their curriculum up to the age of 16.

2 Youngsters should undertake science studies that occupy 10 per cent of curriculum time from age 11 to age 13, 15 per cent in the year from age 13 to age 14, and 20 per cent of curriculum time across years 14–16. This will mean an increase in the proportion of time spent on science for many and a decrease for some. The curriculum framework chosen should reflect the nature of the school and the young people within it.

3 The science studies which are undertaken should be broad, in the sense that they should include elements of astronomy, biology, chemistry, computer science, earth science, electronics, physics and technology. The approach to science studies should display structural coherence, continuity and balance.

4 The science curriculum for all young people should be relevant to their personal experiences and to their present and future lives. It should contain sufficient technological content to provide a bridge to the Craft, Design and Technology curriculum, which all should also experience.

5 As with all other work, science studies should be coordinated with the rest of the curriculum so that individuals follow an overall programme which is broad, balanced and appropriate to their needs.

6 The curriculum encountered by young people should evolve in line with changes in society. The young people themselves, their parents, teachers, prospective employers, trades unions and further educators should have an influence on the process of evolution. Any interested adult should be welcome to participate in the process of science education in the classroom, on the same terms as the young people.

7 Science studies should contribute significantly to the health education of young people, thus enriching the science curriculum and enhancing its effectiveness.

8 In accordance with recommendation 2, the content of school science should be reduced radically so that
- the areas studied are thoroughly understood;
- a better balance is achieved between content/knowledge and skills/processes;
- opportunities are provided for students to make practical use of their scientific knowledge and understanding;
- economic, environmental, political and social implications receive adequate attention;
- post-16 provision is enhanced.

9 School science should cater for the particular needs and aspirations of female students. This should be accomplished through radical changes in the form and content of the science curriculum and the approach to teaching and learning. These processes must also assist male students in their appreciation of science.

10 Young people should encounter a variety of teaching approaches in their science lessons, the approach used being carefully matched to clearly specified learning objectives.

11 Young people with special learning requirements should have full access to the range and breadth of science studies laid down in these recommendations. Additional curriculum opportunities should be available for those whose motivation or capability can encompass them within the time available.

12 School science should aim to engender in young people the realisation that progress in science has never been the sole prerogative of the Western European mind; that the most advantageous approach to technological problems may differ at different places and times; and that human beings in the past often made scientific strides commensurate with the rate of progress familiar in the twentieth century.

13 Science studies between the ages of 11 and 16 should grow from good practice in earlier years. Active and self-directed learning should become the educational norm, thus easing the transition between the primary and secondary phases of education.

14 Teachers of science and their pupils should move together towards an appreciation of how their science studies relate to the worlds of work and leisure. The Review hopes that periods of time spent outside school in places of work will become part of the curriculum for

every young person and also be seen as an essential part of the career development and job satisfaction of teachers.

15 Assessment of progress by the youngsters themselves and by their teachers should be used formatively, so as to assist in the learning process as well as to monitor achievement. The assessment mechanism used should be carefully matched to the learning objective in hand.

16 Science teachers should spend some of their working hours furthering their own expertise in order to maximise both their job satisfaction and their effectivenes in helping young people towards enjoyable and effective science studies. Such periods might be spent meeting constructively with their colleagues, undergoing school- or institution-based in-service training, pursuing and enhancing their own scientific interests, or gaining relevant academic qualifications.

SECTION THREE

Resource implications

Before the recommendations outlined in Section Two can be put into practice, the implications in terms of resources must be considered. These are discussed below in terms of the groups of people who will be affected, *viz:*

- children,
- science teachers,
- science departments,
- schools,
- Local Education Authorities,
- the Government of the day.

It will become clear to the reader that we do not mean just financial resources, important though these are. We are essentially trying, with respect to each of the above groups, to answer the question:

> *What implications does 'science for all' have for me?*

Also, we hope that this section does not suggest that the Review expects all recommendations to be implemented immediately. The aim is rather to provide information to assist those concerned in decision-making about priorities. We are all aware that there is no Good Fairy to wave her wand and provide limitless resources overnight.

For children

> *. . . a very low proportion of pupils (at age 15) demonstrate the kind of conceptual understanding towards which much routine school practical work is aimed.* **(3.1)**

> *Only a third to a fifth of 15-year-old students used scientifically accepted ideas on plant nutrition in written responses to three APU questions.* **(3.2)**

> *That's not an element, Miss, that's aluminium foil.* **(3.3)**

For the good of all the children in schools, the science education community has to put immense efforts into solving the problems expressed so cogently by the above quotes and by legions of others we could have chosen. Let those who rally to calls for retention of standards be sure that they understand which standards they wish to see retained. Successful implementation of the SSCR recommendations given in Section Two of this Curriculum Guide will lead inevitably to 16-year-old children with a different outlook from those of the present day.

These children of the near future will:

- have a reasonable grasp of a wide range of scientific concepts;
- be impatient of spoon-fed information, but interested to enter into learning where their views are given due weight;
- be used to and welcome working in peer groups of varying size where their own input and that of other members is fully appreciated;
- be familiar with a number of teaching strategies which they realise are helping them towards defined learning objectives;
- be able to enter with confidence into scientific situations which they have not met previously;
- appreciate the power, the use to humans and the limitations of science;
- have worked in situations which led them towards an understanding of the place of science and technology in twentieth century society;
- be active and self-directed people, with a genuine curiosity about scientific matters, who are keen to continue their learning in school and after leaving it.

For science teachers

Some implications of the Review's recommendations for science teachers are listed below.

1 A teacher has a responsibility to 'find out what the pupil knows then teach to it'. **(3.4)**
2 There will be a reduction in syllabus content and thus a greater onus on teachers to construct courses that reflect the needs and aspirations of pupils.
3 Teachers will need a greater willingness to
   - engage in self appraisal and identify their own in-service needs;
   - participate actively in their own career development;
   - enter into discussions with colleagues to combine their own identified needs with those of the department and the school, and of the young people within them.
4 Teachers will have a responsibility to keep what they and their colleagues are doing continually under review in an attempt to keep the pace of change in science education commensurate with that of society.

For science departments

The implications for an individual science department are discussed in **Better Science: Making it happen**. For science deparments generally, it is hoped that the questions which follow will be of assistance.

Changing over

The department should ask itself the following questions:

1 Do all children study science up to the age of 14?
2 Is that science broad and balanced for all of them?
3 Does it build satisfactorily on the science the children studied before joining us?
4 Does it provide a sensible preparation for the science courses we are about to implement in the 14–16 age range?
5 What organisational framework best suits us in implementing broad and balanced science for the 14–16 age range?
6 How does what we are proposing to do match with the aims of the school as approved by the Governing Body?
7 How does what we are proposing to do match with the agreed aims for science education laid down by our Local Authority?
8 What changes must we make in ourselves, in our teaching, in our technical support, in our laboratory and other resources, and in our relationships with other curricular areas before we can begin our chosen course of action?
9 What changes will we therefore need to make to our post-16 provision?
10 What action do we need to take to inform and persuade the head teacher, other staff, governors and parents?
11 How are we going to satisfy children, parents, local employers and higher education that what we are doing is better than what was done before?

Several of the SSCR Curriculum Guides will provide ideas as to how these questions might be answered. In particular, the work of the Review in the period 1986–89 will give as much help as possible in answering question 8. This problem is, in any case, less difficult to solve than is often imagined. However, what the Review cannot do is provide finely detailed, complete and off-the-shelf answers to the first seven questions. Nor should it, for it is essential that schools and the departments within them examine their own situation and answer the problems for themselves.

For schools

We do not propose to deal in any detail with the implications of 'science for all' for a whole school here, believing as we do that this subject is thoroughly tackled in **Better Science: Making it happen**. Suffice it to say that we believe no school can implement 'science for all' without considering the whole curriculum on offer. We would exhort careful consideration of recommendation 5 in Section Two by school staffs, head teachers, governing bodies and parents' associations.

For Local Education Authorities

The Review could not, of course, present the problem of 'science for all' in a way which would give detailed assistance to each and every LEA. In the Appendix we give a concrete example from Rotherham Metropolitan Authority. We believe that there is much in their work which, for the general reader, will illuminate the scale of the problem. We are most grateful to this Authority, both for the original work which went into the document and for their permission to reprint parts of it in this Curriculum Guide.

General thoughts

What we hope is clear from the preceding examples and the Rotherham Metropolitan Borough Council's report, is that 'science for all' cannot be implemented at no cost.

> *Many, but by no means all, of the developments necessary will require extra resources, and the pace of progress is bound to depend on the rate at which those resources can be made available.* **(3.5)**

Each Local Authority, in our view, has a clear duty:

- firstly, to commit itself to a broad and balanced 'science for all' programme as a matter of policy and without delay;
- secondly, to give full and immediate backing and resources, possibly on a preferential basis, to those of its schools attempting to implement such a policy;
- thirdly, to support fully the initiatives of such schools before the public at large, who will show the inevitable reservations consequent upon any such change.

For the Government of the day

The present Government has shown itself in two ways to be a supporter of changes leading to broad and balanced science courses for all young people. Firstly, by the issue of its own policy statement (**3.5**). Secondly, by its overt support of the work of the SSCR to the extent of providing extra funding through the auspices of the School Curriculum Development Committee for dissemination of SSCR recommendations over the period 1986–89.

The Government is to be congratulated on these two initiatives. However, there are *four* further

ways of achieving the end which the Government clearly desires:

1 Her Majesty's Inspectorate should use, as a major criterion in their inspection of school curricular provision, the progress each school is making towards implementing the policies of the DES and the SSCR.
2 Specific resource should be allocated, according to need, for:
   - in-service training courses to help teachers achieve a broad and balanced science curriculum;
   - funding to allow Local Authorities to provide advisory teachers and local support for schools trying to implement 'science for all'. This funding would cover the books, equipment, technician help, laboratories etc., necessary for the programme.
3 Encouragement should be given to those responsible for post-16 provision, including the GCE advanced level examinations, to build their programmes and syllabuses on pre-16 courses. Such encouragement could include a general review of post-16 provision, with one aim being closer coordination between familiar post-16 options and other alternatives such as AS levels, CPVE (Certificate of Pre-Vocational Education), BTEC (Business and Technician Education Council) and so on.
4 Resources should be allocated to a large-scale training programme for industrialists and those who work in further and higher education which would alert them to the changes in school science and enlist their active support.

APPENDIX

Rotherham Metropolitan Borough Council Department of Education

The original reply from Rotherham to the SSCR document *Science Education 11–16: Proposals for action and consultation* (**A 1**) was a highly detailed document which, at a length of 18 closely-typed A4 sides, cannot be included in its entirety in this Curriculum Guide. However, it has been of such great value to the SSCR that a summary version follows which gives the full sense of the original without the full evidence which it offered. Rotherham responded in detail to section 8.5 of that document, which is outlined below to set their comments in context.

8.5 Science Teachers, Local Education Authorities, Education and Library Boards and Science Teacher Associations

It is essential that any proposals to change the form and content of secondary science education should command the support of science teachers and their employers. Whilst we feel it is important to build upon and further develop existing good practice, our proposals do have profound implications for teachers and those who support them. In particular our proposals:

(a) are based on a rationalisation of the time that should be allocated to science which, as we have indicated, commands the support of the Association for Science Education, the Royal Society and the Department of Education and Science. Such a time allocation means that many students will, in the future, study more science in school, although a minority will study less in years 4 and 5. Would this time allocation create any major problems assuming that the basic arguments in this paper are widely accepted?

(b) reflect a genuine desire to create an appropriate interaction between science, technology and society whilst at the same time enabling existing specialist staff to contribute fully to new programmes. The Review will, in due course, produce detailed proposals for initial and in-service teacher education programmes and we would welcome views on the content and approach of such programmes. What would you see as priorities?

(c) will involve designing approaches to teaching and learning that meet the broad requirement of teaching less content more effectively and doing so in the context of the real world. This suggests that one of our major concerns will be to augment standard laboratory work with a range of additional teaching and learning strategies including group work, project work, resource-based learning, computer-aided learning, and individualised learning, together with extending opportunities for experiential learning through science and technology-based work experience and/or community involvement. Providing we can demonstrate a better match between learning objectives and teaching strategies and accepting that appropriate in-service support can be provided, what further constraints should we attempt to overcome? Would schools be willing, or able, to react to pressure for more flexible allocations of time and resoures?

(d) will be supported by a wide range of tested and carefully evaluated teaching and learning materials, and much of the effort of our development teams will be directed to this end. Given the new balance we are seeking to achieve between content, skills and applications, what are your priorities with respect to the materials support you will need?

(e) will establish a new balance between content, skills and applications whilst leaving open the question of how the science curriculum might be organised. One alternative is to rely on separate inputs from teachers of biology, chemistry and physics – an alternative that will make heavy demands on teaching teams in terms of planning and coordination. Another alternative is to move towards combined or integrated courses which require teachers to work outside narrow specialisations. We would welcome comments on these alternatives and some indication of the implications of these strategies in man-power and support terms.

(f) link the work we are initiating in science education with the broader aspects of curriculum review being undertaken by the local education authorities. In this context we would welcome advice from authorities as to how our work at the local and regional levels can best support continuing review procedures. What models and exemplars should we attempt to produce during our development phase?

(g) are based on the assumption that structural changes can be negotiated successfully with employers and further and higher education. Assuming that this can be achieved, do you see any other major obstacles to the development of science teaching programmes along the lines outlined in this paper? We are not concerned here, of course, with the fine detail and content of the alternative programmes.

continued in next column

***Box 2** Section 8.5 from the SSCR document*

Authority reply to the SSCR proposals

The Authority would wish to support the broad aims of the Review which seek to:

(i) reduce the content of science examination syllabuses;
(ii) allow all pupils to study the main areas of science up to the age of sixteen;
(iii) allow pupils to pursue more relevant science courses;
(iv) give teachers the opportunity to develop more effective teaching skills.

In reply to the specific consultative section 8.5 the following is offered:

8.5 (a) Proposed time allocation

Many of our schools already work to the time allocation suggested for the age range 11 to 14. It is in the range 14 to 16 where the proposed changes would have most effect. In all our schools, to insist that all pupils study science in some form for 20% (at least) of their total curricular time will mean an increase in existing provision. This would mean more resources in all our schools in terms of teachers, laboratories, laboratory technician time and capitation if we are to maintain our existing standard of provision. In the absence of suggested/recommended class sizes for these groups it is difficult to quantify the requirements and indeed it would seem that some recommendation on group size may also emerge from this Review. However, we would estimate that, in order to maintain our present level of laboratory provision, something like twenty further laboratories across our twenty-one secondary schools would be required at a conversion cost (without building) of something like £12 000 per laboratory. This does not take into account the unpredictable effect these changes may have on advanced level uptake in sciences. Conversion also implies that rooms presently used by other departments would be taken out of use and may need to be replaced. More capitation would be required by science departments – a measure which again would have implications for other departments in the school because this would not simply be a 'one-off' increase but a permanent 'bigger slice of the cake' for science.

More laboratory technician time would be required to service laboratories. If, by reducing content, teachers will have more opportunity to do practical work with pupils, this problem would be even greater.

The need to find more science teachers could create immense problems and may result in a lowering of standards. At a time when the standard of new entrants into science departments locally is encouragingly high, this would be a most undesirable, even retrograde step. A major concern here would be that, in order to maintain teacher standards, head teachers may feel tempted to make do with the existing numbers of science teachers and increase the numbers of students per group. This number already varies greatly from school to school. Again it is hoped that recommendations may come from the Review for optimum group sizes for students at the different ability levels, given Central Government backing and appropriate support in manpower terms.

8.5 (b) Priorities for in-service training

The proposals suggest that there is a likelihood of teachers needing more experience in teaching the skills of science and in teaching across disciplines, so that heads of department will have more flexibility in timetabling as well as allowing for a fully integrated approach. Motivation of 'reluctant' science students in years 4 and 5 will also cause some problems for teachers.

Our schools strongly feel that any INSET required would be most worthwhile if done in school time, perhaps with some secondment. Local advisory INSET bodies may have to be set up to promote and advise on good practice in any new methodology. LEA advisers already have a heavy commitment and may not be able to devote the time required without further help and would themselves require some initial 'training'.

Teachers would have to be given the opportunity to take time off periodically to brush-up on teaching skills and initially must be given the confidence that they would be able to build on the skills and experience which they already have.

8.5 (c) More flexible time and resources

If this means giving teachers more time to teach in the manner they would wish, with emphasis on science process rather than content, then we would agree wholeheartedly. If resources are to be centralised in science departments then consideration must be given to those schools where geographical lay-out makes this impossible. In these cases more laboratory technician time would need to be provided. Community involvement would have to be very flexible as the attitides of, links with, and constitution of communities around schools vary so greatly.

The Authority would always support any initiative which would help teachers develop more effective teaching methods. Present content-overloaded syllabuses frustrate teachers wanting to do this and place the emphasis on always 'getting through the syllabus'.

8.5 (d) Materials support

There would be a need for a wide range of published materials from which to choose in order to suit all pupils, all schools, and all teachers, whose approach in any case will vary widely.

Initially, time for resource development, perhaps using local development group work, and money to buy resources, would be in great demand.

8.5 (e) Separate sciences or integrated?

Any new scheme *must* allow for flexibility of approach within the two extremes of biology/chemistry/physics and integrated science. Modular science courses are very effective in many of our schools and many would wish to continue with this style of organisation. A 'core plus options' approach would lend itself to the latter and allows departments more flexibility.

8.5 (f) Models and exemplars across the whole curriculum

For the broader implications of the Review's proposals it is essential that educationalists from outside science are consulted directly (Chief Education Officiers, Senior Advisers, Head Teachers, etc.) for it is such people who can take an objective overview of the implications across the curriculum and whose support it would be necessary to secure in the event of any required major changes emerging.

The models and exemplars required must include the following:

(i) different methods of organisation of science timetables
(ii) different organisation of whole curriculum timetables
(iii) more effective methods of staff deployment
(iv) positive INSET advice for schools and LEAs
(v) information which would reassure teachers in other subject areas in schools of the need for and value of the proposed changes.

8.5 (g) Other major obstacles

The above changes *could not* be achieved within existing levels of provision and implementation but would require further resources of finance, manpower and time from Central Government.

Specific comments from schools

The remainder of the Rotherham document comprises replies to the SSCR document from nine individual Science Departments identified as follows:

School	Type (all comprehensives)	Number on roll
A	11 to 18 co-ed	1788
B	11 to 16 co-ed	1112
C	11 to 18 co-ed	1678
D	11 to 18 co-ed	1535
E	11 to 16 co-ed	832
F	11 to 16 co-ed	970
G	11 to 16 co-ed	782
H	11 to 16 co-ed	1053
I	11 to 18 co-ed	1619

The replies are individually and collectively of great interest and may be viewed complete, by any interested person, in the SSCR archives. In this Curriculum Guide, we reprint two of the replies, from Schools C and I, which we believe encapsulate most of the issues raised by the replies.

School C

1 There were differences of opinion but the department as a whole was in agreement with the opening statement and the aims of the proposed new direction of study.
2 It was felt that not all syllabuses were overloaded – it was deemed easier to cope with physics which is easily compartmentalised, less so with chemistry, much less so with biology with its much wider application.
3 It was felt that we often underestimate what less able children can do and that mixed ability classes would benefit them, with different aims for individual children controlling the content and not *vice-versa*. The teaching of skills is most important.
4 Teaching time is too low for 11–13, about right for 13–14, very arguable for 14–16 years range. For example, at present two-science pupils get ten, forty-minute lessons per week, three-sciences get fifteen.
5 Opinion was divided about the suitability of the proposals as training for potential A level candidates. Some feared a lowering of standards, others regarded the new proposals as ideal training.
6 Implementation will require greatly increased spending on resources, in-service training, smaller classes, and internal time for staff to adjust and sort out strengths and weaknesses. A modular system could allow for staff interests – many biologists teach the subject because they find it much more interesting and satisfying – the background knowledge of living things is not acquired overnight by physical scientists.
7 It was felt that the whole exercise would be a sheer waste of time without corresponding changes in the methodology of other subjects and attitudes in primary schools. The cultural environment of girls encourages them to prefer 'certainty of knowledge areas'. In science they are less certain of what is required.
8 When all is considered, the prime concern should be for what is right for our pupils in the context of a technological society; in the home, industry, commerce and medical advances.

School I

8.5 (a) Major problems concerned with proposed time allocation

Year	Existing groups	Teacher periods	Proposed groups	Teacher periods
1	10 at 2 periods/week	20	10% (at 11–13 years old)	
2	10 at 2 periods/week	20	2.5 periods × 20 groups =	50
3	12 at 4 periods/week	48	15% (at 13–14 years old) 4 periods × 12 groups =	48
4/5	Biology 7 at 3 periods	21	20% (at 14–16 years old)	
	Chemistry 8 at 3 periods	24	600 pupils (average	
	Physics 8 at 3 periods	24	class size 25) means	
	Modular science 12 at 3 periods	36	24 groups 5 periods × 24 groups =	120
	Sub total	105		
Totals		193		218

Difference: an extra 25 teacher periods

Conclusions

This is equivalent to another full-time teacher of science. It was mentioned that 'science' may be taught elsewhere in the curriculum, possibly under the banners of home economics, craft and design, and geography. It is possible that (a) if the existence of this is proved and (b) it is taught under aims and objectives more in line with those of a science course, then this school already closely approximates to SSCR time recommendations.

However, it was thought unlikely that 'science' did exist in a recognisable form in other departments. The point was also made that if science content did exist elsewhere, the science department had a 'right' to enquire gently into teaching methods and objectives and to suggest changes to bring them into line with those operating in specialist science courses (or in line with the proposed aims of the SSCR document – Section 4.2).

Box 3 *Teacher time (remember we are on a 25 period week)*

Year	Laboratory periods Needed now	Proposed	Laboratories available (periods)
1/2	40	50	75 (all junior labs)
3	48	48	Senior labs avaiable
4/5	105	120	= 8 × 25 = 200 lab periods
(6	30	(30))	
Sub total	183 (years 3–6)	198 (years 3–6)	200
Total	223	245	275

Points

1. 6th form figure of 30 is a minimum number needed – this year there are 58 6th form periods.
2. While the total number of available laboratory periods suggests leeway, the real problem is hidden in two respects:
   (i) the number of available 'senior' labora-tories is too low – blocking will create difficult timetabling
   (ii) the number of available senior physics/ chemistry laboratories is proportionally less then senior biology laboratories (5 out of 8), so the real 'crunch' will come in timetabling 3rd–6th form physical science.

Box 4 *Laboratory space. We would experience a major problem here if we assume that all science lessons should be taught in a laboratory*

8.5 (b) *Priorities in in-service training*

The department felt that any training should be on short-term secondment and should not involve evenings/weekends. It was also felt that such re-training should take place in advance of the start of any such scheme. It also followed that centres concerned with teacher training must prepare young teachers for such a radically different approach to science teaching.

Areas in which we felt there was need for in-service training included:

(i) integration – training across all skills in all subjects rather than in one specialisation
(ii) technology
(iii) problem-solving
(iv) group work, project work, resource-based learning, computer-assisted learning, individualised learning.

8.5 (c) *Flexible allocation of time resources*

The department would react favourably to such a new system. Whether or not we would be able to undertake it would depend on its manageability. One problem we do envisage concerns our present one-hour periods. There are no double lessons below 6th form level. We feel that single periods of 'effectively' 50 minutes might be inadequate for some of the open-ended investigation work. Creating double periods causes timetabling problems as other subjects may not need double lessons, e.g. maths and languages.

8.5 (d) *Other support needed*

(i) More technician help will almost certainly be necessary. It is difficult to judge the requirements of local group work but it will almost certainly involve more varied and complex practical work.
(ii) It is not unreasonable to put in a plea for lower class sizes to cope with the *implied* extension of practical work. My figures of teacher periods required were based on a group size of 25 pupils. Reduction to an average class size of 22 pupils would necessitate an extra two science teachers (instead of an extra one).

8.5 (e) *Team teaching versus integration*

The department felt divided on this issue. Some teachers feared the loss of teaching quality that may occur with an integrated approach, others regarded it as a challenge. Team teaching would pose difficulties of organisation, while an integrated approach posed personal difficulties. Much would depend on the quality of resource packages made by the project teams.

8.5 (f) *Good examples of science curricula*

We had little time to discuss this issue. Speaking personally (for biology) the ABAL scheme for A level biology contains interesting ideas and a very varied approach. The MACOS scheme perhaps points out the way biological science should be taught in the first three years. Scottish Integrated Science gives core and extension work at different levels. I cannot do more than refer in general philosophical terms to Shayer and Adey's *Towards a Science of Science Teaching*, page 145, the section on characteristics of the 'New Science Curriculum'. The four stated characteristics seem excellent starting points.

8.5 (g) *Other major obstacles*

(i) *Resources*

It was felt that the SSCR document implied considerable extra expense in terms of consumables and equipment wear and tear. It is difficult to be precise, but the department felt that the stated aims implied money.

(ii) *Less able pupils*

The department felt that a certain lack of realism was evident in the aims with respect to less able pupils, e.g. aim 4.2 (b), first paragraph and 4.2 (d), both paragraphs.

We noted the phrases '. . . careful attention has been given to problems of progression and cognitive growth' (4.3 (c)). We welcomed this but could not see the match between this and some of the aims, which suggested a fairly high cognitive level. If we are to believe Shayer and Adey (*Towards a Science of Science Teaching*, page 9), then 70% of all pupils do not reach Piagetian formal operations by the age of 16, and slightly less than 20% are still in the early concrete stage at age 16. Aims which mention 'evaluate evidence', 'solve problems', 'discuss and reflect upon' seem (intuitively) beyond the reach of less able pupils.

(iii) *Other points raised*

It may appear that we have been critical of the scheme and somewhat unenthusiastic. I believe there is considerable liking within our department for the broad ideas presented. We all felt they were intrinsically right. Our enthusiasm, however, was tempered by a certain amount of cynicism. It was mentioned that the teachers taking an active part in the local group development work should be (a) paid for their work at a rate amounting to considerably more than merely token payment and/or (b) be involved in this work while on secondment. Some of us felt that we have been involved in many curriculum changes over the last ten years that have meant considerable work. We felt unwilling to commit

ourselves to such a major work-intensive project (on development teams) without (a) payment and (b) a greater possibility of a successful outcome than seems apparent over, say, the present 16+ criteria/aims/examining system. If the present person at the DES vacillates over such a minor change as 16+, what would he do over this scheme?

General reading list

The bibliography which follows is not intended to be an exhaustive review of all sources which may be of use to anyone interested in science education. Nor, through lack of time and resources, can it be a *review* of such literature. Readers searching for such a review are referred to *Issues in Science Education* by Lillis and West. Rather, the following is a list of major sources which have proved to be of considerable use during the research and development stages of the SSCR. Most of the titles which follow would be of interest to the many science teachers who have little time to indulge in their own research but who are concerned to continue to learn about science education.

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The Secondary Science Curriculum Review (SSCR) was set up in 1981 to stimulate, through working groups of practising teachers, the development of science studies which would help to provide an appropriate science education for *all* young people growing up in a scientific and technological society — whatever their abilities or career intentions. Its concern was not only with the science curriculum — its contents, purposes, teaching methods and resources — but also with the role of science in general education and within the whole school.

The **Better Science: Curriculum Guides** are based on the combined experience of the Review's Central Team and the working groups. Each Guide deals with a different but significant area of concern. Together they aim to assist teachers both in devising a broader and more balanced approach to science studies and in enhancing their professional development. The intention throughout is not necessarily to provide answers but rather to provoke and encourage teachers' thinking about the various topics addressed.

This Guide, **Better Science: Key proposals,**

- introduces the SSCR and its ways of working;
- summarises briefly the main recommendations of the Review towards achieving science for all young people;
- discusses the resources needed at school, authority and national levels;
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Heinemann Educational Books/Association for Science Education for the School Curriculum Development Committee

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